says Prof. H. C. Frankenfield, "are not so marked along the Atlantic and Gulf coasts as along the Great Lakes, and fogs forms with nearly equal temperatures when the latter do not differ sufficiently to cause complete condensation in the form of rain or snow. Frequently rain will be falling at one place on the coast while at the next station, only a short distance away, there will be dense fog. It is usually observed, however, that at the place where the rain is falling the wind velocity is greater than where the fog prevails and a decrease in the velocity would doubtless be at once followed by dense fog."

Frankenfield gives the following seasonal percentages of dense fog for the south Atlantic coast; Winter, 46; spring, 27; summer, 5; and autumn, 22. For the Gulf coast: Winter, 54; spring, 30; summer, 1; and autumn, 15.[4] Along the Gulf coast the maximum frequency of fog is from the northwest coast of Florida to the northeast coast of Texas, the number of foggy days increasing toward the west. The greatest frequency is in January; scarcely any occur from June to September.

Weather conditions are described as very favorable for aviation in Florida by A. W. Brooks, Weather Bureau official at Miami Airport, who states that during the first year of operations, air mail failed to leave Miami on schedule only once—September 28, 1929—when a hurricane was passing through the Florida Straits into the Gulf of Mexico. Dense fogs are rare in southern Florida and are mostly shallow ground fogs which quickly disappear after sunrise. A solid overcast of low stratus or nimbus clouds is rare in southern Florida, Brooks states, except during a passing shower or when a hurricane is in the vicinity.

CENTRAL STATES

By VINCENT JAKL

[Weather Bureau Airport, Fort Crook, Omaha, Nebr.]

The portion of the country considered in this section comprises those States or portions of States lying between about the eighty-eighth and one hundred and fifth meridians, and extending from the Canadian boundary to the southern limits of the country, but not including the immediate Gulf coast.

Over this area, in common with other portions of the country, the average conditions of ceiling and visibility can be judged to a fair degree of accuracy by the general average amounts of precipitation. Ceiling and visibility are both controlled in large measure by the amount of moisture—both visible and invisible—contained in the air, while the moisture element is in turn roughly proportional to the average frequency and intensity of precipitation. We therefore find that there is a progressive improvement with respect to these conditions from east to west, slow at first, and then more rapid westward from about the ninety-eighth meridian, as the more arid regions of the plains States are approached.

As regards visibility, another contributing factor to this graduation of average conditions from east to west is the general lessening in the amount of smoke from cities and industrial regions, parallel to the diminishing density of population westward. There is also an appreciable improvement in average visibility from north to south, this latitudinal difference being, however, confined to the colder months. As may be inferred, the Southern States enjoy a relative infrequency of snowfalls, as compared with Northern States, and snowfall, as is well known, diminishes visibility much more than rainfall. Moreover, the more pronounced changes in temperature and the precipitation that frequently attends such changes, which Northern States are subject to, are conducive to greater frequencies in light to moderate fogs. Dense fogs are brought about by special conditions, therefore we find that there is no important variation in this element with latitude, but a noticeable variation with longitude; that is, greater frequency in dense fogs over eastern than over western sections on the average. The more general use of natural gas for heating in the Southern States is perhaps not a negligible factor in bettering the conditions of visibility there as compared with Northern States.

The advantage that the Southern States enjoy is not really as great as might be apparent from the foregoing, as the favorable conditions mentioned are partly offset by low-pressure areas that first become evident as such in the Southwest and pass northeastward. These southwestern Lows develop with northeastward progress, and cause widespread precipitation attended by low clouds and poor visibility. In their pronounced form they are peculiar to the colder months, and affect the middle and much of the southern portions of this area.

The western portions of the area likewise are affected by a condition peculiar to them that modifies the general statement that visibility always improves westward. These are the dust and sand storms that affect the arid regions, more particularly those of the Southwest, and are most likely to occur in spring when the surface winds are on the average the strongest. The diminished visibility resulting from these storms is a factor to be reckoned with; nevertheless it is of far less importance than the products of moisture that are the chief cause of poor visibility over eastern sections.

A fair indication of relative weather conditions may be had from a comparison of the number of cloudy days over different portions. A cloudy day is one on which the average cloudiness was equal to eight-tenths or more of an overcast sky. Over Minnesota and Wisconsin the average annual number is 130 to 150, while over the western Dakotas it is 80 to 100, and in the Plains region of Wyoming and Colorado, 60 to 70. In Iowa and eastern Nebraska, it is about 100, in Illinois and eastern Missouri and Arkansas, 110 to 120, while in northern and western Texas, from 30 to 50.

Over all the area low clouds are much more frequent and more prolonged in winter than in summer. Those in summer are largely in connection with thunderstorms, which are usually of short duration as compared with the overcast rainy or snowy conditions of winter. In winter, clouds that are low enough to be a hindrance to flying are usually associated with fogs, mists, snows, and other forms of low visibility.

The distinction must be made between the number of days on which unfavorable conditions of ceiling and visibility are recorded as occurring sometime during the day, and the number of days that they are persistent throughout the day, as in the former case a flight may merely be delayed, while in the latter it may have to be canceled for the day. The relation of the former to the latter is at least 2 to 1. The proportion is smaller in winter than in summer; that is, a poor condition is more likely to persist throughout the day in winter than in summer; it is also more likely to persist throughout the day over eastern sections of the district than over western sections.

In any generalization such as this, exception must be made of local peculiarities. For example, river valleys are more susceptible to radiation fogs than surrounding

[4] Weather Forecasting in the United States, Chap. IX.

more elevated regions. On the other hand, over the more rugged portions of the country, places that rise quite high above their surroundings are subject to more frequent low ceilings.

For the area as a whole, it may be said that clouds lower than 1,000 feet (300 meters) occur on an average two or three times as often in winter as in summer, and probably twice as often at night and early morning as in the afternoon. They are generally rare on summer afternoons, except as they occur in thunderstorms. From meager statistics available, an approximation may be made that over the eastern portion of the area, a condition of low clouds, or of dense fogs, or heavy rains or snows, is recorded as occurring some time within the 24 hours on probably 20 to 30 per cent of the days in winter, while in summer the frequency may be about half that amount. Over the western portion, this frequency dwindles to perhaps half those figures for the western fringe of the area, possible even less for the extreme southwestern portion. If we consider only those days on which unfavorable conditions persisted throughout the day, the number will diminish to not more than two or three days a month in the colder season, and to practically none in the summer months, even over the least-favored sections in the east.

Visibility is better in summer than in winter, and better in the afternoon than at night or morning, probably averaging poorest in the early morning daylight hours when fogs and haze abound. Over the eastern portion of the area, visibility less than a third of a mile (0.5 kilometer) occurs on about 6 to 8 per cent of the days on winter mornings, and about 3 per cent of the days on summer mornings; on about 4 to 6 per cent of the days on winter afternoons, and 1 to 2 per cent of the summer afternoons. Visibility greater than three miles (5 kilometers) prevails during about 70 to 85 per cent of the time. Over western sections, statistics if available would show a decidedly more favorable condition.

ROCKY MOUNTAIN STATES

By HARRY M. HIGHTMAN

[Weather Bureau Airport, Salt Lake City, Utah]

Ceiling and visibility are perhaps of more importance to aviators in the Rocky Mountain region than in any other part of the country, owing to the fact that airways must traverse regions of great variations in elevation. Airplanes traversing a course over this region must pass over wide expanses of rough broken country, uninhabited desert areas, high mountain ranges, sometimes rising abruptly 4,000 feet (1,200 meters) or more above the general surface level, or through mountain passes, often narrow, with mountain peaks towering above in the near vicinity. Thus ceilings and visibilities that would be considered ample for flights in other parts of the country could not be considered at all for flights in this region.

On account of the great variation in surface elevations along the airways in this region, ceiling heights are very variable, and a determination of the average height along an airway would be of little value. However, it may be stated that the average height of ceilings in the Rocky Mountain region is greater than the average height in other parts of the country. At Salt Lake City, for example, it has been found that ceilings are seldom low enough to measure by means of a ceiling light, or ceiling balloons, that is, lower than 2,000 feet (600 meters), except when precipitation is occurring, or fog prevailing.

Ceilings low enough to interrupt airplane traffic are due almost invariably to low-lying clouds, or fog, in the higher mountain regions which obscure the mountain tops and close in the mountain passes. The most important and frequent causes limiting visibility are fogs, heavy snow, and floating frost in the air. The causes limiting visibility to a lesser extent are smoke, usually occurring in the vicinity of cities, dust storms, and occasionally blowing snow and heavy rain.

Low clouds in the Rocky Mountain region nearly always occur in connection with a low or cyclone over or in the vicinity of this region. Often ceilings are high enough for flights in the lower valleys and comparatively level plateau regions, but too low to allow flights in the mountain region.

Fogs are almost wholly a winter-time phenomenon in the Rocky Mountain region. They are nearly always of the radiation type and form most frequently in the mountain valleys and over the plateau regions. They are more frequent and extensive when the country is snow covered and an anticyclone has settled over the region. These fogs occasionally cover wide expanses of the country in the region surrounding Great Salt Lake, and sometimes continue without a break for a week or longer at a time. Their depth is usually not very great and it is often possible to fly over them.

Heavy snow, most frequently occurring in the mountain regions as snow squalls, is the next in importance to fog as an element limiting visibility. These squalls, usually local and limited in area, often set in suddenly in the mountain regions, blotting out passes and mountain sides, and are thus a serious menace to flying. They are one of the most difficult elements to deal with in airways forecasting in this region.

Frost in the air (floating frost crystals) usually occurring with fog formation, is not an infrequent occurrence in the Rocky Mountain region during periods of cold weather in winter, and sometimes materially restricts visibility. This phenomenon is often observed with a clear sky prevailing overhead, and with a temperature of 10° to 15° F. (−12° to −9° C.) or lower.

Smoke occasionally becomes dense enough during the winter months in the vicinity of the larger cities materially to restrict visibility, especially at nighttime. A mixture of fog and smoke is a quite common occurrence in the vicinity of Salt Lake City during the winter months, and occasionally becomes dense enough to prevent landings and take-offs.

Dust storms occur occasionally over the desert regions, during dry periods of summer and autumn, when high winds prevail. Dust is sometimes lifted several thousand feet in the air and occasionally becomes dense enough to obscure landing fields.

There is very little interruption to flying owing to poor ceiling and poor visibility in the Rocky Mountain region during approximately seven months of the year; that is, from May to November, inclusive. During May and November some of the higher mountain passes may be closed in by low clouds during stormy periods, but this condition seldom lasts as long as a day at a time, and probably the average occurrence is less than three times during a month. From December to April, inclusive, conditions are very unfavorable for flying approximately one-sixth of the time. The three winter months, December, January, and February, are decidedly the worst.